THE TECHNICAL NEWS BULLETIN OF THE NATIONAL BUREAU OF STANDARDS / March 1974

DIMENSIONS NBS

A PUBLICATION OF THE UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DIMENSIONS NBS

MARCH 1974 / Vol. 58, No. 3 / ISSUED MONTHLY

CONTENTS

Nat. Bur. Stand. (U.S.) *DIMENSIONS/NBS*
CODEN : NBSTAR 58(3) 49–72

Superintendent of Documents Catalog No. C13.13:58/3

Library of Congress Catalog No. 49–26527

Cover: A large percentage of the energy produced in this country is consumed in the home. This issue of DIMENSIONS/NBS discusses some of the Bureau's projects that aim to reduce energy waste.

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

The Institute for Computer Sciences and Technology

Center for Radiation Research

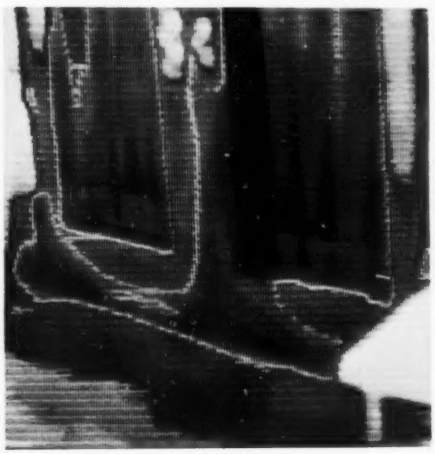
Center for Building Technology

Center for Consumer Product Safety

Formerly the TECHNICAL NEWS BULLETIN of the National Bureau of Standards.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $6.50, foreign, $8.25, single copy, 65 cents. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1976.

Facing the Energy Squeeze



Thermographs are used to identify and locate heat leaks in buildings. Surface temperature variations are shown as shades of gray. Warm areas are light tones, cool are dark.

NOT very long ago, Americans thought of energy mainly as an attribute children often had too much of. Today, many of us see it as a commodity that is suddenly, to an alarming extent, in short supply. The fact is that we've spent a good deal of time, money and technology getting ourselves locked into a system that demands more than current resources can provide.

Although there is no cure-all for the present condition, groups have been at work, both in the private sector and in government—including the National Bureau of Standards—in the areas of energy conservation and energy production long before energy became a problem in the public mind.

At present the Bureau has underway more than 20 conservation programs and a host of projects relating to power production. A main focus since 1940, when the first NBS environmental chamber was completed, has been investigating the performance of whole buildings and their heating systems. This focus, long in developing, is appropriate since an estimated 75 percent of our energy is spent in combined commercial, residential and industrial uses.

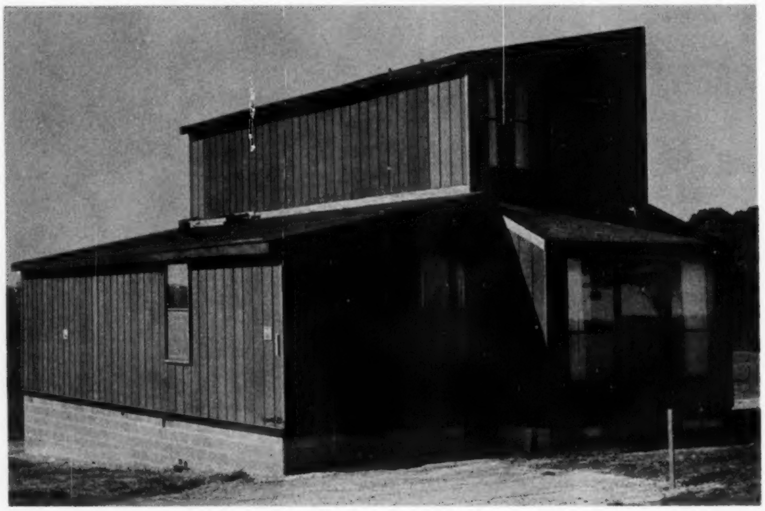
Early studies evaluated the efficiency and effectiveness

turn page

SQUEEZE *continued*

of various heating systems and the construction characteristics of houses that affect energy utilization. From such research we have learned how much energy can be saved.

One study of a four-room frame house, conducted in 1950, showed that filling the wall cavities with vermiculite insulation and applying storm windows reduced the measured heat loss by 37 percent at an outdoor temperature of —16.7 °C (0 °F). Since that time we've learned that improved methods of building design, construction and insulation can cut energy use by up to 50 percent.



To develop standard test procedures for solar systems, NBS engineers will fit this townhouse, located on the NBS Gaithersburg campus, with a solar energy collector and storage system.

The Townhouse

The NBS project receiving the most attention in recent months is a townhouse study. In November, First Lady Patricia Nixon and the President's Special Assistant Virginia Knauer accompanied Bureau Director Dr. Richard W. Roberts on a tour of the facility situated on Bureau grounds at Gaithersburg, Maryland.

Their visit served to highlight a program initiated to test NBS-developed computer techniques for estimating the energy requirements of homes, office buildings, schools and hospitals. The new methods are much more precise and rapid than previous approaches. Laboratory experiments with an experimental masonry building showed that heating loads calculated by the new techniques were much closer to measured values than loads calculated with earlier less sophisticated approaches.

To see if the computer program was valid for a typical home, NBS purchased a house on the open market and installed it in a 2,000 cubic meter environmental chamber. Here, outdoor temperature patterns can be rapidly simulated and controlled—temperatures from —45.6 to 65.6 °C (—50 to 150 °F).

The house, factory-made in three modules, is the end-unit of a townhouse configuration that could extend the length of a city block. Construction is wood, with heavy insulation, including storm windows, to meet new Federal Housing Administration standards. The house cost $14,000 at the factory door and about $600 to transport it 320 kilometers (200 miles) to NBS from Bloomsburg, Pennsylvania. With the costs for land and foundation, this house in today's market would probably sell for $28–38 thousand.

Delivered by truck and installed in the test chamber, the townhouse was then completely furnished and instrumented to measure its energy consumption and indoor thermal environment when subjected to several winter and summer temperature patterns. Over 4,500 meters of instrument wiring were used and data was gathered from 300 stations every 6 minutes around the clock while the weekly living pattern for a family of six was simulated.

55 Percent Saving

The energy measurements made on the townhouse verified the predictions of the new computer program to within 5 to 10 percent and provided quantitative information on how much energy is lost through ceilings, walls, windows and doors and from air leakage. The townhouse tests showed that use of insulation saves 55 percent as compared with not using insulation.

Tests also revealed that single-window glass transmits 10 times more heat than a well-insulated wall, per unit area, and 5 times more than double glass. The total area of glass is also very important. In this house, windows and doors are about 15 percent of the exterior wall area, compared to the usual 15 to 30 percent.

Caulking around windows and doors and the use of weatherstripping effectively reduced the exchange of air between the inside and outside. In this house, the air change was only ¾ of its volume each hour when the outdoor temperature was about —17 °C (0 °F). Houses typically have 1.5 to 2 air changes under these conditions.

Measurements on the house showed that turning the thermostat back 5 °C (9 °F) for 8 hours overnight saved 11.5 percent heating energy when the temperature outdoors was about —6 °C (21 °F).

Lights and appliances consume a considerable amount of energy, depending on their efficiency and amount of use. Studies show that for the same size house with the same appliances, the energy consumption of one house could be twice that of the other because of the way lights and appliances are used and the way doors, windows and heating and cooling equipment are operated. NBS is investigating both appliance energy use and the operating practices of building occupants.

Related Programs

The knowledge gained from the townhouse has had application in a growing number of related areas. Funds from the NBS budget and those of other agencies have gone into expanding the nucleus of work begun on Bureau grounds to other buildings and in other regions. The General Services Administration's office building in Manchester, New Hampshire, for instance, is discussed elsewhere in this issue—as is the New York City Schools study. These are examples of the work being done by the Bureau on buildings and power generating systems for building complexes in four broad program areas:

- Immediate/contingency (What can be done on an emergency basis).
- Near term/operational (What can be done within a short time).
- Retrofit (Remodeling for energy efficiency).
- Design.

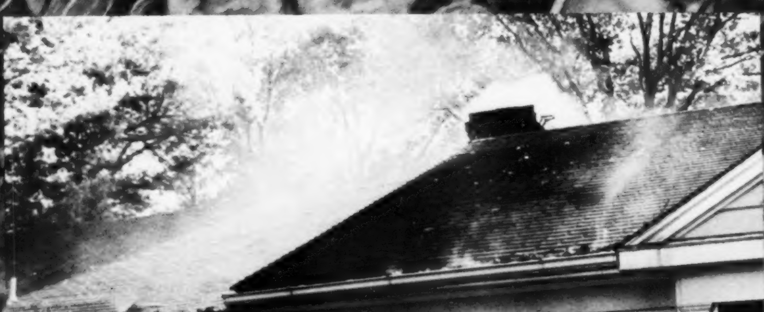
First Lady Pat Nixon checked the sensitivity of a relative humidity gage during a tour of the NBS experiment townhouse.

Beyond Buildings

In addition to building technology, NBS has studied the economic affects of conservation measures, from the initial cost increase to the long-term savings from greater energy efficiency. The Bureau has made information available to a wide audience, including the consumer, on topics ranging from improved building design to how to choose an energy efficient air conditioner. Another consumer booklet becoming available through NBS advises how to save energy in the home.

The energy problem is a complex issue but the first step toward a solution lies in learning how to use energy conservatively and efficiently. The following articles highlight NBS efforts in that direction. □

Without Insulation Your Dollars Slip Away



IF you are living in a wood-frame house, particularly one built 20 years ago or more, your home could be using anywhere from 45 to 65 percent more energy than necessary, and you are spending more money than you need to on gas or electric bills to cool it in the summer and warm it in the winter. An insufficient amount of insulation in the ceiling or over a crawl space or in the walls is costing you money.

Specific heat leakage paths on the uninsulated Bowman House are identified by smoke released by pyrotechnic generator inside.

Further, most houses built that long ago were constructed with only single pane windows. In most houses 20 years old, the caulking around the windows is cracked or chipped away and either little or no weather-stripping exists to tightly seal the windows and doors when closed. Add to that all the cracks and separations that might be expected from two decades of use and the homeowner can literally feel his dollars slipping away.

Under the direction of Douglas M. Burch and George E. Kelly, mechanical engineers with the National Bureau of Standards' Center for Building Technology, a number of modifications on an existing 20-year old, one-story, 24.4 meter x 9.1 meter (80 ft x 30 ft) wood-frame house on the NBS grounds, Gaithersburg, Md., known as the Bowman House, will be made to study possible energy savings.

Seven Energy-Conserving Options

Burch says that approximately 75 percent of all energy consumed in residential and commercial buildings is for space heating and cooling and water heating. Since the energy consumed by newly constructed buildings in the next few years will only account for a small portion of the total, significant savings must be found for existing dwellings. The alterations, known as "retrofitting," for residential buildings include seven technical options:

- Adding additional insulation into the ceiling for a total of 15.2 cm (6 in).
- Adding 7.6 cm (3 in) of insulation in the walls where none now exists.
- Placing insulation under the floor.
- Adding storm windows and storm doors.
- Caulking, weather stripping and sealing air leaks.
- Adding awnings over the windows.
- Improving the heating and cooling systems.

Measurements to be Made

According to Burch, the study will be done in six phases. The first, consisting of winter heating tests to be conducted early this year, will determine the actual energy use of the house as it now stands before retrofitting. Only modifications necessitated by neglect (minor repairs) will be made in advance of the tests. Measurements will determine fuel consumption and the heating input and energy output of the oil-fired, forced-air furnace system. Indoor air temperature and outdoor weather will be measured. Separate air infiltration, smoke leakage and thermographic studies will be used to identify specific heat leakage paths.

A tracer gas will be used to measure the rate of air infiltration for different outdoor conditions. For this, a small volume of sulfur hexafluoride (SF_6) is injected into the house. Once the structure's own ventilation system disperses the gas, frequent periodic readings of the gas' concentration are taken in various areas of the house. The rate of reduction in concentration caused by fresh outside air replacing the mixture inside is a direct measure of air infiltration.

For the smoke leakage test, a portion of the house is pressurized and a white pyrotechnic generator is activated inside. Visual observation of the exterior identifies air leakage paths. Infrared photography also is used to locate cold spots inside the house, such as along wall-ceiling joints and around windows and doors. The camera is sensitive only to the low-frequency heat spectrum outside that of visible light. A calibrated flow meter installed between a 20.8-dekaliter (55-gal) oil drum and the boiler will measure the fuel consumption. Placing the oil drum on a scale and simply weighing the oil as it is used will provide a check on the fuel rate.

The summer cooling test, the second phase, will determine the energy used during the warm months. Proposals call for equipping the Bowman House with a heat pump system to replace the furnace prior to the summer test. The electrical input energy, the heat energy removed by the heat pump and the outdoor weather factors will be measured for at least 2 weeks of severe summer conditions. Since the rate of air infiltration and building heat transfer are significantly different for summer and winter conditions, these will be repeated for the summer tests.

Areas of worst heat leakage are single-pane windows, poor weather stripping and caulking around windows, wall-ceiling joints, insufficient roof insulation and an uncovered kitchen exhaust.

The third phase planned, set for the fall of 1974, will be to retrofit the house, employing the seven technical options mentioned previously. In addition, NBS will install moisture sensors between the interior and exterior walls to detect condensation in the insulation possibly occurring during the winter.

The fourth and fifth phases, the winter and summer post-retrofit tests set for 1975, will be a repeat of the tests conducted this year—but on the modified house. In the final phase, the energy use of the insulated Bowman House will be compared with the earlier measurements and engineering techniques for predicting performance in other houses will be developed. □

Office Building to Slash Fuel Use

By 1976, some 600 Federal employees will be working in a specially designed building that could consume 40 percent less energy than a conventional office building of the same size.

The $6.5 million, seven-story structure is to be erected in Manchester, N.H., by the General Services Administration (GSA). It is expected to demonstrate energy conservation in office buildings and to provide office space for several Federal agencies. Its unusual exterior shell, unique selective lighting, an assemblage of low-power-consuming heating and cooling systems on different floors were specified by the National Bureau of Standards (NBS). It houses an extensive and highly technical monitoring network devised by NBS to determine which energy-conservant methods incorporated in the building are most effective.

Paul Reece Achenbach, Chief of the Building Environment Division at NBS, says that 15 percent of all energy used in the United States is consumed by commercial buildings and 19 percent by residential buildings. Achenbach points out that three-quarters of the 34 percent combined commercial and residential use is for space heating and cooling and water heating. He estimates that as much as 30 percent savings in energy consumption can be made through better building designs; an additional 15 to 20 percent could be gained by improved utility systems design and operation.

Office buildings frequently have as much as 50 to 60 percent of their outer walls made of glass, usually only one pane thick. Single panes of glass transmit about ten times as much heat as a moderately insulated wall of the same size during the winter. Consequently, GSA expects a considerable number of design changes from their architectural and energy-consultant firms for the Manchester Project.

Thicker Walls, a Square Floor, and Less Glass

The Thermal Engineering Systems Section of the NBS Center for Building Technology studied energy-saving designs and made recommendations to GSA. According to Dr. Tamami Ku-

Artist's concept of southwest corner of Manchester Project building. Recessed from walls to retain heat, windows consist only of upper portion of the left half of each fin-divided wall section on west side of structure.

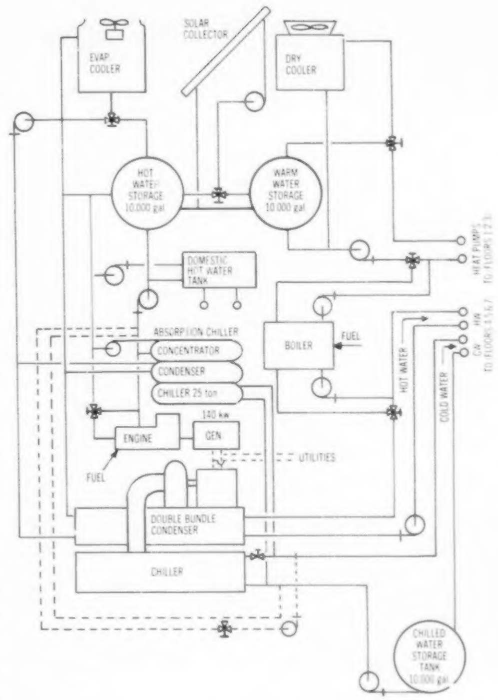
suda, who leads the project at NBS, a 33 percent savings is possible in the annual energy consumption over what has been normal GSA design practice. The results of the study indicate that the shape of the building should be as square as the site permits (36.6 m by 30.5 m; 120 ft x 100 ft). The square layout provides a maximum floor area with a minimum outside surface to be affected by climate. The building will be constructed on a north-south axis and will take advantage of the shading from nearby structures.

The walls will be thicker and better insulated than is normal practice for office buildings. Present plans call for 1.2 cm (½ in) gypsum board and 1.9 cm (¾ in) furring fastened to 30.4 cm (12 in) of masonry. Insulation placed on the outside of the concrete will probably be urethane (5.5 cm or 2½ in) or polystyrene (7.6 cm or 3 in). Because of this wall, the structure should have more thermal stability and use the thermal mass of the building more efficiently than a conventional design. The exterior will be aluminum.

Arrangement of service areas inside will permit the north side of the building to be windowless. Window area elsewhere will be cut to about 13 percent of the total wall surface. The windows will have double openable panes of glass with venetian blinds located between the panes. They will be recessed and shielded from direct summer sunlight by fins on either side and by overhangs.

Variable Air Volume System

An energy-conserving feature, called the variable air volume (VAV) system, will be used in the building for supplying the right amount of cool air in response to the temperature of the core sector requiring air conditioning in winter because of the heat produced by the lights and occupants. The VAV supply principle is more energy-conserving than many air systems which regulate only the supply air temperature (variable air



Schematic of central system for Manchester Project. Only the engine generator and the conventional boiler (indicated by arrows) are fuel consuming; the other equipment operates on waste heat.

temperature systems) and use the so-called "reheat" principle. In the reheat system, air is usually cooled to 12.7 °C (55 °F) to lower its moisture content and then reheated to maintain the desired space temperature and relative humidity.

In the lower three floors, the excess heat from people and lighting in the core zone will be captured and, by means of a "unitary closed-loop heat pump system," will be channeled to the perimeter zone (outermost 4.5 m, 15 ft). If needed, additional heat can be supplied to the water loop system by a solar collector to be mounted on the roof. One possible design being considered for the collector panel would have a series of black-painted copper pipes carrying water to be placed under two sheets of glass for warming by the sun. The warm water will be collected and stored in two 378.5 kiloliter (10,000-gal) tanks which, in turn, are connected to the loop system.

In the upper floors, warm return air from the core will be pumped through the building's central air-handling system for cooling by a 60-ton water chiller supplying another large tank. The heat rejected by the chiller at its "double-bundle condensor" will be fed to the four-pipe "fan-coil" units to heat the perimeter of those floors.

The chiller-condenser unit is to be powered by an engine-generator, which also saves energy by recovery of heat from water jackets and exhaust gases. Waste heat of the engine-generator at a temperature of 93 °C (200 °F) will be drawn off and used to generate domestic hot water for washrooms.

Zone Lighting

Another feature of the project provides that lighting can be individually regulated to save energy. In most present offices, an entire building, floor or hallway might have to be illuminated while one person works. In the Manchester building, the office will be completely "zone lighted" by means of frequently spaced switches.

continued on page 70

Measurement of Energy Utilization

AN INSTRUMENTATION CHALLENGE

MEASUREMENT technology plays an important role in any energy conservation project. Scientists and engineers are unable to calculate the energy savings resulting from certain construction processes unless they can accurately measure such indices as temperature, air leakage, heat transfer or the insulating quality of various materials.

One proving ground where such measurement technology is being utilized is the "Bowman House," a 20-year-old wood-frame dwelling located at the National Bureau of Standards, Gaithersburg, Md., site. There NBS technicians are evaluating the energy savings resulting from application of insulation, sealing of window leaks, installation of more efficient heating and cooling systems and other modifications to this existing building.

Air Leakage Measurement

One technique being employed by NBS involves a complex instrument called an "abridged gas chromatograph" which is used with a "tracer gas" to detect rates of air infiltration. Even when a house is sealed with caulking and weather-stripping around windows and doors, outside air does leak in to replace and refresh the inside air, as a result of wind and chimney effects. In summer and winter, such air leakage also changes the temperature of the house. By injecting a known quantity of a detectable tracer gas into the house and taking repeated readings of its decreasing concentration, NBS can determine how rapidly inside air is being replaced.

Dr. Charles M. Hunt of the Thermal Engineering Systems Section at NBS explained that technicians will inject about 10 cc (less than the volume of a ping pong ball) of sulfur hexafluoride (SF_6) into the Bowman House's ventilating system. This harmless amount will allow them to stay inside to make concentration readings from samples collected from different parts of the house. Samples may be collected either with a small hand pump, or by means of a branched system of tubing extending to all rooms, or simply by sampling from the return air to the furnace blower.

A valve introduces the air samples containing tracer gas into the chromatograph while argon, a carrier gas, flushes the alumina (aluminum oxide) column. Here the SF_6 is separated from the other components. The separated gases are then sent through an electron capture detector for measurement. This detector contains tritium foil, an electron source, which bombards the gases creating a standing current. SF_6 and other strong electron capturing gases decrease this current temporarily, thus forming the basis of measurement. The lower the concentration of tracer the less the current is decreased. This system can detect as little as $\frac{1}{2}$ part per billion.

Thermography

The Bowman House will also involve testing with thermographic techniques, infrared photography, to identify and locate specific heat leakage paths under summer and winter conditions. The thermographic system displays a television picture showing surface temperature variations as different colors or shades of gray. In the color system there are 10 color-coded bands in the thermal picture. A warm indoor surface, such as an insulated wall in winter, will appear as a lightly colored region. On the other hand, a cool surface, such

as a window in winter, will appear as a darkly colored region. Cracks in wall-ceiling joints, separations or missing sections of insulation and poorly sealed window sashes appear as a color-coded region which is in contrast with the rest of the thermal picture, permitting thermal defects to be readily identified. The technique can sense temperature differences as small as 1 °C.

Conventional infrared photography using normal camera equipment and infrared film has very limited use in the field of thermography because the glass lenses are opaque to most of the infrared spectrum, significantly reducing the sensitivity of the instrument. In addition, since the film housing is not cooled, the infrared film is exposed to thermal radiation from the film housing. Television thermography, as used by NBS, is equipped with an optical system, consisting of silicon lenses and germanium scanning prisms, that are transparent to infrared radiation in the spectral ranges 2-5.6 microns. The thermographic camera consists of an indium antimonide (In Sb) photovoltaic detector that is cooled with liquid nitrogen.

Frank J. Powell (right), Chief of Thermal Engineering Systems Section, and Thomas W. Watson, mechanical engineer, watch as Chock I. Siu, mechanical engineer, uses the guarded hot plate apparatus (on table) to determine the resistance of insulation to heat flow.

Thermal Conductivity Standards

Thermal insulation properties play as important a role as air infiltration in determining energy usage. In order to make information available to the building homeowner on energy conservation through the use of increased amounts of insulation, the thermal conductivity of various types of materials must be known to designers, architects and engineers. NBS plays a key role in this process by furnishing measured reference standards to other labs and by providing data for handbooks, architectural books and textbooks for calculating the rate of heat flow through the insulation.

Thomas W. Watson, a mechanical engineer with the Center for Building Technology at NBS and currently Vice-Chairman of the Insulation and Moisture Barrier Committee of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., explained the NBS guarded hot plate apparatus for measuring the thermal conductivity of insulation. The unit consists primarily of a heating plate 20.6 cm (8 in) square and .3 cm (1/8 in) thick with a central metering section 10.3 cm square. Two nearly identical test specimens of insulation are sandwiched between the surfaces of the plate and two cooling plates of the same size. The range of mean temperature during operation of the apparatus is —18 to 55 °C (0 to 130 °F). The apparatus is shielded from room conditions by an insulated metal box. The air in this box is maintained at a constant temperature and a very low relative humidity.

During a test, a constant temperature difference is maintained between the hot and cold plates. NBS calibrated copper-constantan thermocouples are used for measuring temperatures and temperature differences.

The rate of electric energy dissipation in the central metering section is measured and from these data the "k-value" or thermal conductivity of the insulation is computed. The more power required to keep the hot plate at the desired temperature, the poorer the insulation and the higher the k-value. For example, fibrous glass board has a value of 0.24 Btu/hr ft^2 (°F/inch), commercial gum rubber's value is 1.1 and silicone rubber has a thermal conductivity of about 2.5. All three of these materials are supplied to other laboratories as calibrated reference specimens. The NBS guarded-hot-plate method is fully described in and conforms to the American Society for Testing and Materials (ASTM) specification C-177, Standard Method of Test for Thermal Conductivity of Materials by means of the Guarded Hot Plate. □

THE National Bureau of Standards is currently cooperating with the New York City Board of Education under a grant from the National Science Foundation (NSF) in developing a public school building that could provide a significant energy use reduction.

While the program is too new for any firm figures of savings to be ready yet, NBS is encouraged by the studies conducted on other energy-conservant buildings, such as the General Services Administration-NBS office building, called the Manchester Project, to be located in Manchester, N.H. There NBS expects savings as great as 40 percent.

The School Building study will be done in four phases. The first, recently begun, will involve a pre-design analysis to be completed by surveying a cross-section of secondary schools in New York City to determine a norm of construction and energy consumption. Phase Two will involve predictions of energy use from alternative engineering options and the design of an instrumentation and data collection system. The design and construction of the facility comprises the third step; data collection and evaluation, the last.

The Board of Education has commissioned Richard Stein and Associates of New York City to design the school. The entire project will require about 4 years to complete.

Dr. Stanley T. Liu, mechanical engineer for the Center for Building Technology (CBT), leading the project for NBS, says that the New York City Board of Education will make available a 3-year record of fuel oil and electric energy consumption for each school included in the survey, taken on a monthly basis. NBS will compile the data from ten schools together with survey data to identify a typical profile for the "average" school. The analysis will take into consideration such factors as the type of construction, the physical size of the structure, the interior environmental conditions, the length of the school day, its nighttime use for community programs or athletic events, weekend activities and, of course, the number of students.

continued on page 70

NBS Helps Design Energy Saving School

Although large window areas provide considerable natural lighting, they transmit heat ten times as readily as an insulated wall.

HOME ENERGY SAVING TIPS FROM NBS

U.S. DEPARTMENT OF COMMERCE • National Bureau of Standards

America's demands for energy have been increasing rapidly. As a result, there are shortages of some fuels and consumer prices for energy are rising. By practicing energy conservation in your own home you can save money and help ease demands on the nation's fuel supplies.

Among its many services the National Bureau of Standards seeks to bring the benefits of science and technology to the public and to industry. Although these suggestions for saving energy are simple and can often be applied at relatively little cost, or without cost, their effectiveness has been demonstrated by NBS through long experience in the field of building research.

1 Year 'Round Energy Saving Measures

Several steps you can take will provide benefits in both summer and winter. In general, these measures help maintain indoor comfort by preventing heat loss in winter, and loss of conditioned air, or heat gain, in summer.

- **Weatherstrip windows and doors at moveable joints.**

- **Install storm windows and doors.** Keep them tightly closed in winter. In air-conditioned homes, leave most of the windows in place during the summer months; a few windows, however, should be able to be opened easily for ventilation.

- **Install overhead and sidewall insulation.** It is desirable to have the equivalent of six inches of good thermal insulation above your top floor ceiling. Even if you now have three or four inches, it is probably worth increasing the insulation depth to six inches. Insulation of exterior walls is best accomplished during building construction. Adding sidewall insulation to an existing building should only be undertaken with expert advice, because of the possibility of condensation inside the wall.

- **Close and seal all openings into the attic from occupied space.**

- **Close off rooms and closets not in use.**

- **Keep windows tightly closed in the vicinity of your thermostat.**

- **Keep dampers closed when your fireplace is not in use.**

- **Close window draperies,** in *winter* to reduce radiated heat loss through windows, and in *summer* to reduce heat gain from the sun. In winter, you may want to open draperies on windows receiving full sunlight during the day to take advantage of solar heat, but close them again at night.

- **Plant trees or large shrubs around your home.** Deciduous trees (those that lose their leaves in winter) have the special advantage of providing summer shade, and allowing maximum exposure to the sun in cold weather.

2 More ways to save energy IN WINTER

Once you have made sure that your house is well sealed, and that loss of heated air is minimized, other energy conservation steps can save still further on heating bills:

- **Lower your thermostat.** Each 1° reduction in the setting of the room thermostat will save about 2% of fuel in cold climates, and about 3% in moderate climates. If you set your thermostat back 10 degrees for an 8-hour period at night, you may expect to save 10% to 15% on fuel.

- **Maintain an efficient heating plant.** If your heating plant has an air filter through which the recirculated house air passes, you can maintain its efficiency by cleaning or replacing the filter frequently.

  Other measures that will improve or maintain efficiency of the heating plant include cleaning heat-exchange surfaces, proper adjustment of combustion air, and possible installation of smaller orifices or jets in the burner. The equipment changes, alterations, or adjustments should be made by experienced service personnel familiar with your type of heating plant.

Some suggestions pertain only to steam or hot water heating systems:

- **Drain air or water from steam pipes and radiators.**

- **Use enamel, rather than flat paints on radiators.**

- **Dust or vacuum radiator surfaces frequently.**

- **Reflect radiator heat into the room.** you can do this by placing a sheet of aluminum or aluminum foil against the wall behind the steam or hot water radiator.

3 More ways to save energy IN SUMMER

If you do not have air conditioning there are a number of things you can do to make your house more comfortable on hot days. If you do have air conditioning, many of these same measures can reduce the load on the air conditioning system, and so save energy and utility costs. Practicing the *Year 'Round Energy Saving Measures,* designed to seal and insulate your home, is especially important in air conditioned homes.

- **Reduce heat gain from the attic.** When your roof is heated by the sun, your attic may be as much as 40 degrees hotter than the temperature of the outside air. Insulation is the best means for reducing transfer of this heat into the living area. However, if the attic is poorly insulated, and new insulation is difficult or impossible to install because of inaccessibility, you can use an exhaust fan to greatly reduce attic temperatures - and the flow of heat into living areas. Roof and ridge ventilators can also be used to remove hot air from an attic.

- **Shade windows, especially from direct sun.** In addition to use of draperies, there are several means for reducing entry of heat through windows:

  Install awnings, overhangs, or louvered sun screens. Awnings and overhangs can reduce solar heat gain by as much as 80%. They must be properly designed in order that they not trap hot air in the window area.

- **Use light colored paints and roofing materials.** A dark colored exterior surface may get as much as 60 degrees hotter than the air temperature in direct sunshine, while the same surface, painted white, would only be about 20 degrees above the air temperature. It is especially desirable to have the roof color as light as possible - a point to remember when you are planning to re-roof or build a new home.

- **Use hoods over stoves and use exhaust fans in the kitchen, bath, and laundry areas.** Ex-

haust quantities of heat and moisture to the outside during periods when these areas of the home are in use. In air conditioned houses it may be practical to close these areas off from the rest of the house when cooking, bathing, or washing, and rely solely on exhaust fans or natural ventilation through windows or doors opening to the outside.

A few suggestions apply primarily to houses without air conditioning:

- **Take advantage of the daily temperature cycle.** Open windows and draw cooler night air into the house; close up tightly during the day.
- **When ventilating, draw in air from the coolest side of the house.** Investigate the possibility of installing a large exhaust fan in the attic to pull fresh air throughout the house.
- **Use small, quiet circulating fans to provide local air movement.**

Air conditioners–Select the type and size unit that meets your needs

The choice between central air conditioning and one or more room units is largely a matter of cost and personal preference. Central systems generally provide the most effective and economical means of total-house cooling. Individual room units may be most economical from the standpoint of both initial investment and operating cost, especially if you require air conditioning in only a few areas, such as bedrooms.

But whether you install a central system or room units, it is most important for comfort and efficiency that the air conditioner be of a size suitable for the area(s) to be cooled. If necessary, seek expert advice. Your dealer should be able to give advice concerning the size air conditioner unit to suit your purposes, taking into account such determining factors as size of the area to be cooled, the number and sizes of windows, and the direction they face, etc.

For units of any given cooling capacity you should consider buying the most energy-efficient models. Higher efficiency means less use of electricity and lower operating costs.

Operate and maintain your air conditioning system to increase comfort and economy

How you operate your air conditioning equipment will have a significant effect on your comfort and cost of operation.

1) **Individual, or window units.** If the circulating fan has more than one speed, in mild weather, run it at lower speeds. Because most houses have enough natural air leakage for ventilation purposes, the outdoor air damper should be closed for greater effectiveness and economy; it can be opened to speed up removal of cooking or tobacco odors. Turn the unit off if rooms are unoccupied for several hours.

2) **Central air conditioning systems.**
   - **Locate the thermostat control on an inside wall** where comfort is of greatest importance, or in a hallway where it can sense air circulating from several rooms.

3) **Maintenance.** By following a few simple maintenance procedures you can keep your air conditioning system operating efficiently:
   - **Check filters for dust or lint every 30 to 60 days,** and clean or replace as necessary. Allow free circulation around the condenser by keeping shrubbery trimmed.

4 Save energy IN APPLIANCE USE

Beyond their purchase price, the benefits that modern appliances offer must be paid for in energy. Here are several ways to save energy in appliance use:

1) **Refrigerator-Freezer**
   - **Check door gaskets for air leakage.** Close the door on a dollar bill. If you can pull it out easily, the gasket is so loose it will leak air. Replacement of the gasket, or re-adjustment of the latch will save electricity and money.

- **Use manual defrost units.**
- **Clean the condenser coils.**
- **Open the doors only when necessary, and for short periods.**

2) Clothes Washer-Dryer

- **Reduce frequency of use.** Wash only full loads.
- **Use cold or warm water settings.** This requires use of special cold water detergents.
- **Hang clothes outdoors on a line to dry.** Even if you own a dryer there may be occasions when the time saved by machine drying is unimportant.

5 Save energy IN THE KITCHEN

- **Cook several dishes or whole meals in the oven at the same time.**
- **Check the seal of oven gaskets.** Replace them if they leak heat into the room.
- **Use cooking pots of the same diameter as the stove burner or heating coil.**
- **Use tight-fitting lids or pressure cookers to reduce cooking time.**

6 Save energy IN WATER HEATING

- **Insulate hot water storage tank and bare pipes.** It is especially important to insulate pipes that run through cold areas such as a basement or garage.
- **Repair leaky faucets.**
- **Replace shower heads with smaller ones to reduce water flow rate.**
- **When replacing your hot water storage tank, avoid over-capacity.**
- **Consider reducing hot water to 120°F.** Check with your plumber to see whether, in your particular circumstances, this suggestion is practical.

7 Save electricity IN LIGHTING

- **Turn off lights when not needed.** From an economic point of view, it is not a good idea, however, to turn fluorescent lights off, and then on again if you leave the lighted area for only very brief periods of time (up to 10 minutes or so). Repeated starting of fluorescent tubes shortens their lifespan.
- **Use only the amount of light needed for specific room areas and activities.** Reduce general lighting. Provide a high level of illumination only where needed.
- **Utilize daylighting whenever practical.**
- **Use lighter colors on interior wall surfaces and furnishings.**
- **Use the most efficient and practical light sources.** Fluorescent tubes produce more light than incandescent lamps, for a given amount of electricity consumed. Extended service (long life) lamps are less efficient than the ordinary general service variety.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

For further information on energy conservation, write to:

Consumer Information
Public Documents Distribution Center
Pueblo, Colorado 81009

DEPARTMENT OF COMMERCE ★ UNITED STATES OF AMERICA ★

Where from Here?

ALTHOUGH this issue of *DIMENSIONS/NBS* centers on one area of conservation, that goal alone is not the only concern in the field of energy. We know that natural resources do not come in unlimited quantities, and that to deplete them at an even greatly reduced rate is only an interim measure.

A difficult challenge facing science today is to discover efficient means of energy production that will not short change us or future generations. A number of programs in which the Bureau is involved or has an interest take up that challenge.

Solar power, as an example, is being explored at NBS as a supplement to conventional home energy systems. Solar cells mounted on the roof of the townhouse collect and store the sun's energy for use in heating, air conditioning and space heating. The townhouse experiment should result in standard test procedures for solar systems.

Our domestic supplies of coal far exceed our supply of oil. Coal can be used, of course, to heat homes. But by and large, the Nation has switched to a cleaner, more efficient method of heating—namely gas or oil.

Coal can be cleaned for use in high-temperature gas turbines that generate electricity. It can also be transformed into methane, the gas used in many furnaces. The Bureau is involved in research that could lead to discovery of materials better able to withstand the tremendous heat of gas turbines. Other investigations center on problems with impurities and unwanted by-products such as polluting slag and fly ash, as well as difficulty in finding materials that will withstand the conditions necessary to achieve coal gasification. NBS performs studies on materials that relate to coal gasification. For instance, nickel, a catalyst that speeds up the process of changing coal into methane, becomes quickly ineffective when it comes in contact with sulfur, an impurity in coal. By better characterizing the catalytic process, NBS hopes to aid in solving the problem.

NBS is involved in several studies aimed at improving the efficiency and cleanliness with which coal—our most plentiful domestic energy source—can be used.

Another promising means of producing electrical current using coal is magnetohydrodynamic (MHD) reaction. However, the high temperatures of MHD demand materials that can tolerate high heat over long periods. NBS is involved in the effort to develop the right materials for this purpose. One candidate is ceramics.

Nuclear Power

In the final analysis, fossil fuels can serve only as a stopgap; the supplies are finite. One answer to the energy problem lies in nuclear power, both fission and fusion. In fission, the nuclear core of an atom, a system that contains a certain amount of energy, is split; in that process some of the energy is released. In fusion, an opposite process produces a similar result; the nuclear cores of two atoms combine into one, but the one new system contains less energy than the two separate systems. Thus, again, energy is released.

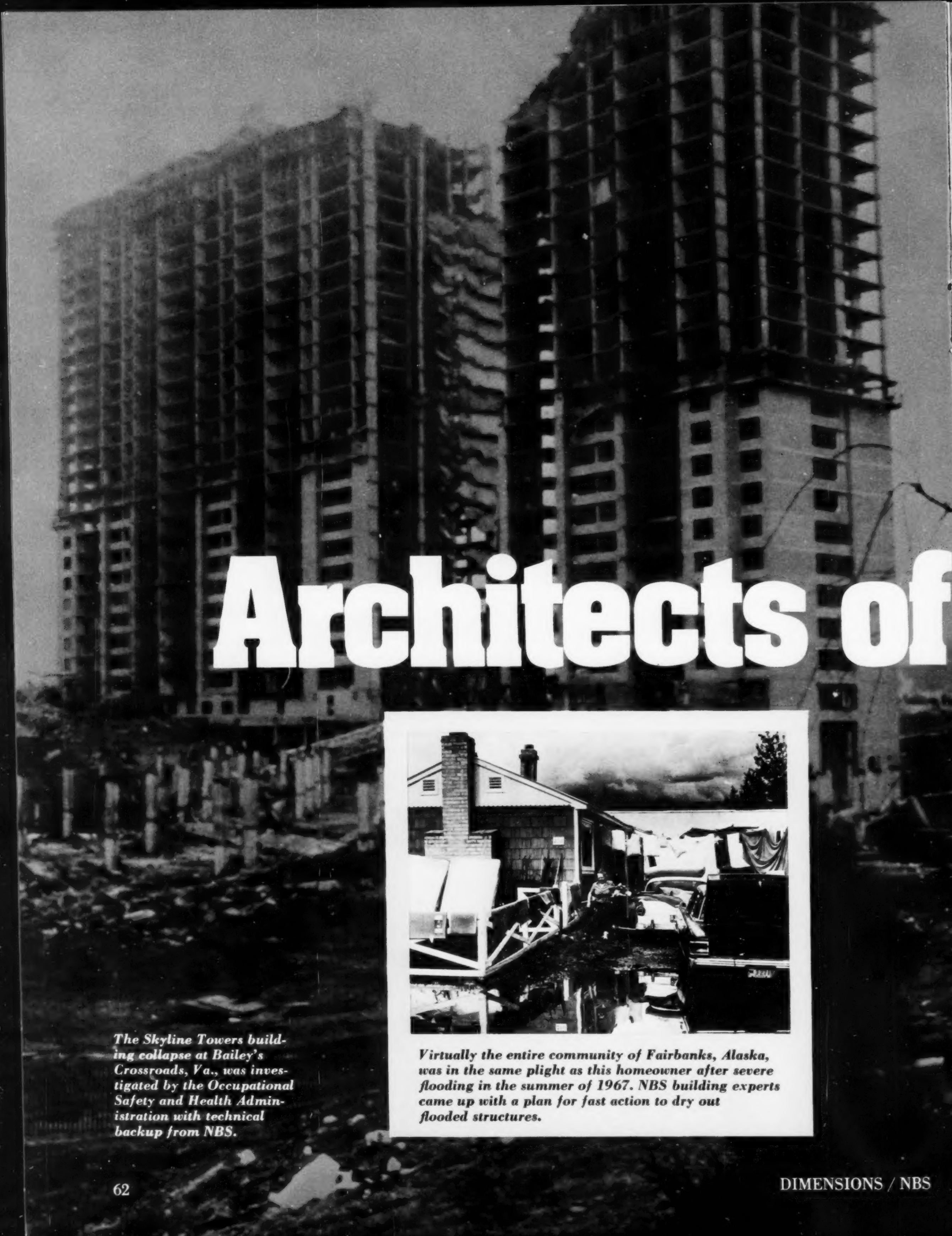
Given the 8 to 10 years currently necessary to plan and build one fission nuclear reactor, coupled with a still developing state-of-the-art, this solution presently supplies only a small part of our total energy needs.

What is the problem with state-of-the-art? At present, our only method of producing nuclear power is through fission. To achieve fission we must mine uranium ore from which we can extract small amounts of essential uranium 235. Certain nuclear power plants, called breeder reactors, are being designed to produce more of the precious "nuclear fuel" than they use. If successful, they will greatly multiply our energy from uranium fission and slow down the depletion of another natural resource.

Fusion

Probably the ultimate solution, still in the theoretical stage, is controlled fusion reaction. Fusion is the process of energy production like that occurring continuously on the sun. It is preferable to fission because it uses

continued on page 70



Architects of

The Skyline Towers building collapse at Bailey's Crossroads, Va., was investigated by the Occupational Safety and Health Administration with technical backup from NBS.

Virtually the entire community of Fairbanks, Alaska, was in the same plight as this homeowner after severe flooding in the summer of 1967. NBS building experts came up with a plan for fast action to dry out flooded structures.

WITH a rambunctious Mother Nature dictating their travels to points ranging from Fairbanks to Biloxi and from Manila to Managua, the disaster teams of the NBS Center for Building Technology (CBT) are developing guidelines for survival in the face of flood or earthquake or wind or wave or collision or fire or explosion.

As Sam Kramer, Charlie Culver and their colleagues in CBT's Office of Federal Building Technology see the problem, it's a matter of not leading with your chin. Twenty-foot tides, 125-mile winds, major earthquakes, baseball-sized hailstones and the like can kill or maim people and rob them of their homes, their possessions and their livelihood, but it is possible to anticipate, ward off or minimize the blows. Where devastated areas have to be rebuilt, the community can apply improved codes and practices to build better than in the past. Immediate recovery activities can be systematically organized and conducted. In preparation for future emergencies, existing and planned buildings can be evaluated for natural hazards so that strengthening features can be adopted or blueprinted.

For example, the Fairbanks, Alaska, flood in 1967 inflicted water damage on every house and business structure, with building damage alone (excluding personal property losses) quickly rising to

An NBS team analyzed structural effects of this costly fire at the Military Personnel Records Center in St. Louis.

SURVIVAL

"Resistance Movement" Sparked by NBS Disaster Teams

$150 million or more and additional damage threatened by the approaching winter freeze. A two-man NBS team flew to the crippled community, stopped for an Army Corps of Engineers briefing and toured the area with Federal and local authorities. Then, through radio messages, leaflets, newspaper articles, public meetings and conversations with homeowners, they advised the people of Fairbanks on how to remove water from buildings, quickly repair heating systems and how to handle walls, vapor barriers, insulation and sheathing for best results in drying out and averting freeze damage.

Devastating 125 mph winds, flash floods and landslides made 1969's Hurricane Camille one of the most intense and costly tropical storms ever to hit the U.S. mainland, resulting in hundreds of deaths and $1.42 billion in property damage along the Mississippi-Louisiana Gulf Coast and in Virginia. But the powerful Camille

turn page

failed to destroy everything in its path and a four-man NBS team spent hard-hit Gulfport-Biloxi area, carefully appraising the storm's effects and taking hundreds of photographs, seeking evidence from which to derive formulae for constructing buildings that would stand up to future Camilles.

Another hurried trip out of Washington occurred early in 1971. Soon after residents of California's north San Fernando Valley were awakened by earth shocks at 6 a.m. on February 9, the White House's Office of Emergency Preparedness called upon NBS to send a structural engineering team to the earthquake area. The initial shock had been followed by more than 200 aftershocks. The earthquake claimed 64 lives and caused monetary damages in the hundreds of millions of dollars. In a detailed monitoring of the quake's structural consequences, three NBS experts were joined by two University of Texas civil engineering professors, arriving at findings and recommendations embodied in the 412-page book, *Engineering Aspects of the 1971 San Fernando Earthquake.*[1]

And so the story goes. The total impact of natural disasters in terms of human life and suffering is difficult to quantify, but property losses in recent years have averaged an annual $1 billion in the United States. President Nixon in his 1972 State of the Union Address called for "new or accelerated activities" aimed at reducing the toll. For NBS, anti-disaster activities are not new but they *are* being accelerated.

Almost total devastation along the beachfront was the rule in 1969's Hurricane Camille. NBS investigators found that surviving buildings were usually those with structural frames or with load-bearing walls running at right angles to the beach.

Wilkes-Barre, Pa., suffered near-total property loss and considerable siltage when Hurricane Agnes raged through twice in June, 1972. An NBS team appraised performance and safety characteristics of mobile homes provided for dislocated families.

In addition to the staggering overall loss of life and property, certain specific considerations underlie both the President's call for stronger action and the NBS response. Among these considerations are:

- The Federal government has major statutory responsibilities for disaster mitigation.
- Some 37 percent of all new construction is directly or indirectly Federally supported. State governments, with constitutional authority for promulgating building codes, are also deeply involved.
- Improved codes and standards can reduce the rate of disaster property losses in new buildings. Acceptable levels of disaster-loss risk require that a balance be struck between the value of lesser risk and the costs of obtaining it.
- Thousands of vulnerable buildings exist in earthquake, windstorm, flood, hailstorm and other disaster-prone areas of the country.

In broad perspective, work on these problems requires a twofold emphasis on fostering building practices that would make structures increasingly disaster-proof and developing post-disaster response capabilities for relief and recovery activities. For these purposes the NBS teams draw upon interdisciplinary support from engineers, architects, chemists, physicists, city planners, economists and psychologists.

In a rounded approach to the complex challenge, the NBS disaster teams start at the beginning by defining the extreme environments that bring on disaster and proceed step by step toward the development

and implementation of improved building practices. In detail, this means focusing on structures, interior environments, durability of materials, fire safety standards and codes, architecture, building economics and thermal and sensory engineering. This research provides knowledge for the development of engineering standards and related measurements.

Technical consultation and advice are provided not only to Federal and State agencies but also to the building industry at large. Close cooperation is maintained with those who draft, promulgate and distribute building standards and codes, including the National Conference of States on Building Codes and Standards (NCSBCS), a group which the states organized and for which CBT serves as secretariat.

Building practices for disaster mitigation are being studied in a major cooperative effort with the National Science Foundation's Research Applied to National Needs (RANN) Program. The object is to close important gaps between research and building practices, because current practices in land-use planning, building codes and inspection procedures often do not reflect new knowledge of extreme loads and the ultimate resistance of buildings. This program—closely coordinated with $25 million of related RANN-sponsored disaster/natural hazard research over a 3-year period—has in its first phase climaxed in a national workshop. Fifteen critical reviews are incorporated into the resulting 474-page volume, *Building Practices for Disaster Mitigation*, describing the state-of-the-art of building practices, with recommendations for improvements and for new research.[2] □

[1] *Engineering Aspects of the 1971 San Fernando Earthquake (NBS Building Science Series No. 40)* is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3. Order by SD Catalog No. C13.29/2:40.

[2] *Building Practices for Disaster Mitigation (NBS Building Science Series No. 46)* is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $5.30. Order by SD Catalog No. C13.29/2:46.

Three of the 64 deaths caused by the 1971 earthquake occurred at Los Angeles County's Olive View Medical Center, shown above. NBS cooperated in an intensive on-the-scene investigation. (Los Angeles Times photo.)

RECENT NBS DISASTER INVESTIGATIONS

Trouble-shooting trips by NBS teams may take them across town or across oceans and are an old tradition dating back to the Bureau's earliest years.

When a series of fires struck large cities in this country shortly after the turn of the century, NBS was soon collaborating with the National Fire Protection Association and Underwriters' Laboratories on comprehensive safety analyses of building materials and designs.

Some recent highlights of NBS disaster activity:

A CBT team went to St. Louis after the July 12, 1973, Military Personnel Records Center Fire and over a period of weeks aided the General Services Administration in scientific sleuthing of the fire's effects on the structural system.

April 1973 tornado damage in Fairfax County, Va., was examined by CBT experts in connection with a Defense Civil Preparedness Agency (DCPA) project for evaluation of the natural disaster vulnerability of existing buildings and formulation of methods to strengthen structures and reduce risks.

The collapse of the 24-story Skyline Towers building during 1973 construction operations at Bailey's Crossroads, Va., was analyzed in a CBT-aided Occupational Safety and Health Administration (OSHA) probe.

A CBT-National Academy of Engineering (NAE) Team was the first U.S. technical group to arrive in Managua to help Nicaraguan authorities after the December 23, 1972, earthquake that left nearly 10,000 dead and more than 335,000 homeless.

After 1972's Hurricane Agnes, NBS/CBT was called in by the Department of Housing and Urban Development (HUD) on a "Top-priority rapid turnaround basis" to appraise the winter heating capability and other performance and safety characteristics of some 16,000 mobile homes provided for dislocated families in Pennsylvania, New York, Virginia, Maryland and West Virginia.

A 1972 gasoline explosion that killed an Annandale, Va., mother and two children at home prompted a CBT-aided National Transportation Safety Board investigation of a construction-triggered accident symptomatic of a widespread hazard in a country criss-crossed by 800,000 miles of natural gas pipelines in and out of populated areas.

HIGHLIGHTS

Aiding Weather Reports

Advisors from NBS are aiding three special energy task forces from the National Oceanic and Atmospheric Administration (NOAA) in their efforts to provide the public with advice on energy conservation. NOAA's weather report service, available to the media, will include general conservation suggestions and, possibly, guidelines for emergency measures when extreme conditions are present.

Legal Metrology Group Set

To advise the Bureau on technical matters before the International Organization of Legal Metrology (OIML), NBS is setting up the U.S. Advisory Committee for International Legal Metrology. The committee's work should help determine the U.S. position on OIML matters through cooperative government-industry effort.

The U.S. policy of supporting OIML objectives involves participation in the planning and heading of studies. To that end, the United States recently assumed responsibilities for developing international recommendations in five major metrological areas:

- General principles of inspection of measuring intruments.
- Measures of masses.
- Weights.
- Measures of electrical quantities and magnetic quantities.
- Pollution measuring.

Ultrasonics Accuracy Improved

To help the enforcement of the Radiation Control for Health and Safety Act of 1963, NBS is developing measurement standards and methods for ultrasonic instruments. As part of this effort, NBC Boulder scientists, working with the Bureau of Radiological Health, have improved the accuracy of ultrasonics power and energy measurements from about 20 percent to the 5 percent level.

Ultrasonics is a relatively new tool that is finding increasing application in medical diagnostics and therapy. However, ultrasonic radiation at sufficiently high levels can cause tissue damage.

Energy Tip Sheet Out

NBS has prepared a tip sheet of energy conserving suggestions for the home. Single copies of the *Home Energy Saving Tips from NBS* are available free of charge from Consumer Information, Public Documents Distribution Center, Pueblo, Colo. 81009.

The insert in this issue is a reprint of "Tips" for *DIMENSIONS/NBS* readers.

Gasoline Dispensers

The maximum price-computing capability of gasoline dispensers manufactured before 1960 is 49.9 cents per gallon, and the unit price of gasoline already exceeds that amount in many parts of the country. Modification of the dispensing apparatus can take more than 3 years. As a temporary emergency procedure, the Bureau has recommended that the unit price dials be set at one-half the selling price. New labels should be affixed to the face of the pump showing that the unit price is "per one-half gallon" and that the total price indicated is "one-half total price."

Removing Graffiti

At the request of the Department of Housing and Urban Development, NBS is studying ways of removing graffiti from walls of public buildings. The project will lead to the establishment of performance requirements for graffiti removal procedures and also for materials that resist defacement by marking devices.

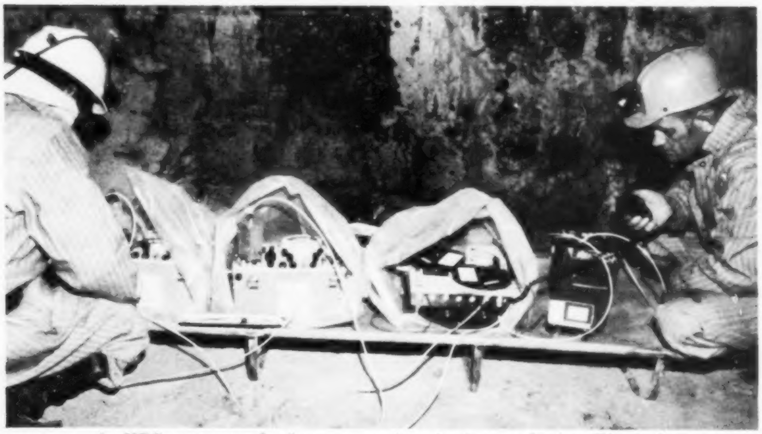
Computer Control System

The Bureau has developed a new concept in adaptive digital control for complex problems too difficult for more conventional techniques—e.g., controlling a mechanical arm. This new concept, called the Cerebellar Model Articulation Controller (CMAC), is based on principles of distributive memory addressing used by the brain in controlling the muscles of the body. CMAC uses commands and sensory feedback data to compute the addresses of control functions distributively stored in computer memory. Possible applications of CMAC include guidance of free-swimming deep-sea vehicles, control of automatic mining and tunneling equipment and automatic operation of assembly and inspection machines.

Carpet Flammability

NBS is developing a new method for testing the flammability of floor coverings that uses a radiant panel to ignite the carpet. Armstrong Cork, Southwest Research Institute and NBS are presently conducting a preliminary interlaboratory evaluation study of this radiant panel test method. NBS will use the results of the study as a guide for full-scale interlaboratory test involving 15 laboratories. The test is designed to measure the fire hazard potential of carpets in high-risk applications. □

New "Voice" for Trapped Miners



An NBS team records electromagnetic noise in a coal mine. Plastic bags protect instruments from mine dust.

A research program which has been completed by National Bureau of Standards (NBS) engineers is aimed at providing miners tolling far below ground with a dependable means of calling for help should

The work, sponsored by the U.S. Bureau of Mines, was prompted by the fact that underground disasters such as cave-ins and explosions also frequently disrupt phone wiring, the miners' traditional link to survival.

Now, engineers from the NBS Boulder, Colorado, laboratories have conducted research into electromagnetic (EM) noise measurement and EM interference in working mines.

This research will help establish communication by EM waves broadcast through the earth instead of the more vulnerable phone system.

The data resulting from the project permit accurate predictions of which Voice Frequency (VF) signals will be intelligible and thus offer a dramatic improvement in the miners' ability to "keep in touch."

To aid this program, portable equipment was devised for on-site EM noise measurement in coal mines. This is essential data, for mine electrical machinery creates intense noise fields that interfere even with wired phone systems. NBS engineers visited several mines to test their equipment, to determine what measurements are needed and to acquire data describing EM noise conditions in working mines.

The earth so effectively attenuates radio waves (about 1-100 MHz) that they are useless for through-the-earth communication. Lower frequency EM waves propagate farther, though. Signals within the band designated Voice Frequency (VF = 300-3000 Hz) have been detected through 457 meters (1500 ft.) of earth when noise fields at the receiver are not so intense as to mask the signal. Thus VF systems deserve thorough consideration.

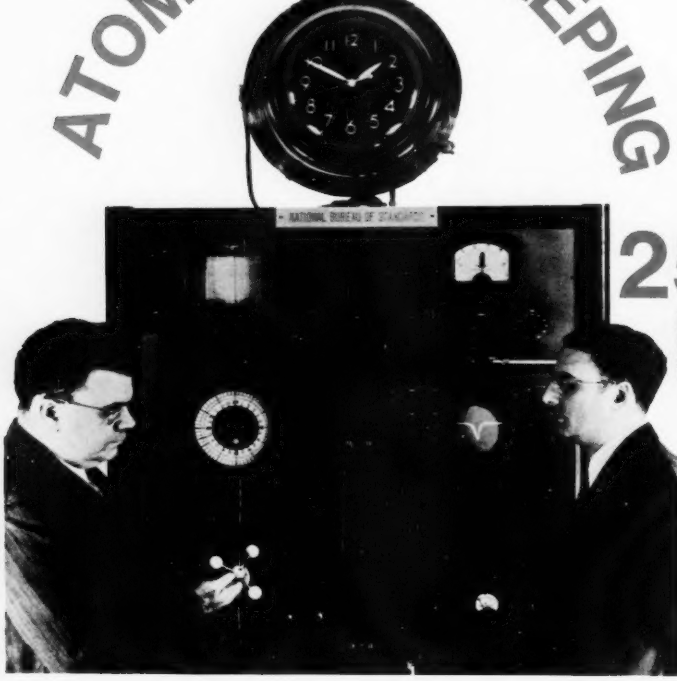
If an engineer were given his choice of location for making accurate measurements, he probably would not pick a working coal mine. Yet, communications engineers must know the noise environment in which a proposed communication system will operate. Therefore, John W. Adams, William D. Bensema and Motohisa Kanda of the NBS Electromagnetics Division, Boulder, designed their equipment specifically for use in mine conditions. They developed systems that were portable, battery operated and "permissible" (all instruments safe for use in a potentially explosive mine atmosphere). A monitoring oscilloscope, because of its high-beam voltage, was not permissible until packaged in an explosion-proof case. In addition dust covers had to be devised for several instruments.

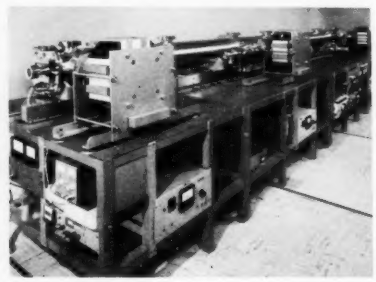
The tape-recorded data NBS gathered constitute the most extensive mapping to date of EM noise in a coal mine. When processed, this data furnished: 1) amplitude probability distributions (APD) at several frequencies, 2) broadband noise spectra and 3) the time, location and antenna-orientation dependence of the received noise fields.

Adams and colleagues employ two systems giving complementary data formats. The Adams and Kanda narrowband (2 kHz) system records the noise field strength at 12 frequencies over the range 10 kHz to 32 MHz. Recordings as long as 20 minutes give a good statistical description of the time variations of noise at each frequency. This data, when presented as APDs, clearly and concisely describes the signal-masking ability of the noise.

The system records magnetic-field noise from 300 Hz to 100 kHz. Several-millisecond "snapshots" from this data are converted to spectra which show how the noise varies with time and frequency. □

ATOMIC TIMEKEEPING 25 YEARS LATER





In 1949, Dr. Edward Condon, former NBS director, and Dr. Harold Lyons, physicist, announced the first atomic clock, which was based on the ammonia molecule. The present NBS atomic clock, an NBS primary frequency standard, is a cesium-beam device.

ON January 6, 1949, Department of Commerce Secretary Charles Sawyer and several National Bureau of Standards scientists announced to the world a new timekeeping system. Totally independent from the centuries old system of basing time intervals on our revolving earth, this device interrelated oscillations of ammonia molecules to a quartz oscillator's frequency and time system. Although no better in accuracy than astronomical time, which changes due to fluctuations in the earth's revolution, this 1949 device acquired the distinction of being the world's first "atomic clock."

Little did Sawyer or the physicists involved know that their techniques would one day lead to development of several highly refined atomic time and frequency standards. Refinement and application of new techniques by NBS and other standards laboratories have established today's extremely accurate cesium-beam standards. These standards provide a highly stable frequency, which in turn defines the unit of time, the second, which is the most accurate base unit in our international measurement system. Since 1967, the second of time has been internationally defined as "the duration of 9,192,631,770 periods of the radiation corresponding to the transistion between two hyperfine levels of the ground state of the cesium 133 atom."

Today's horologist and the general public are unfamiliar with the physicists' vocabulary describing atomic clocks. Instead of familiar terms like "escapement," "pendulum," balance wheel" and "main spring," atomic clock makers are prone to talk of "hertz," "resonance," "detectors," "atomic beams" and "microwave interaction cavities." Although this technical jargon may be formidable to many, atomic clocks perform the same basic function as the mechanical type clocks used since the start of time measurements. Each counts, or in its own way keeps track of a regular periodic phenomenon, often referred to as a vibration or oscillation. The constant rate and repeated oscillation motion of a pendulum or balance wheel permit an escapement to indicate time in seconds, minutes and hours. Refined time sources offering oscillations as high as nine

billion per second are currently used by NBS.

Molecular and Atomic Physics

The 1949 ammonia type atomic clock resulted from the perfection of molecular and atomic physics techniques started in the 1920's. Although these techniques were in their infancy in 1920, physicists were striving to learn how matter interacted with electromagnetic energy (microwave, radar). The study of spectral lines, called spectroscopy, broadened. These distinct lines, the result of electromagnetic energy being absorbed or emitted by certain molecules and atoms at very precise frequencies, were discovered. The first atomic clock used the ammonia absorption line to regulate a frequency emitted from a quartz crystal oscillator. This frequency was in turn used to regulate two synchronous clocks, each set and compared to astronomical time. The quartz oscillator provided the clock's short-term stability, the ammonia absorption line the necessary long-term stability.

Cesium Devices

That same year, NBS initiated research and development of a cesium beam atomic device. A consultant to NBS, Professor Polykarp Kusch, an associate with Professor Isidor Rabi of Columbia University, worked on applying Rabi's magnetic resonance technique to a cesium-beam device. As with the ammonia clock, a quartz oscillator's multiplied signal provided the needed microwave signal. Similarities between the ammonia and cesium clock devices more or less ended at this point.

By applying atomic-beam techniques, a very narrow beam composed of cesium atoms was formed. Emitted from an oven, these atoms passed through a pair of magnets, one on each side of a microwave cavity, and completed their path by hitting a detector. The signal at the detector, in turn, controlled the frequency of the quartz oscillator. The oscillator's frequency was controlled to a very narrow limit, resulting in improved frequency stability and accuracy as compared to the ammonia device.

The first successful detection of the cesium transition used as today's definition of the second was observed in NBS-I and reported in 1952.

The National Physical Laboratories (NPL), Teddington, England, constructed the first cesium-beam standard used for periodic calibration of secondary oscillator time sources. This atomic clock, also using a Ramsey type interaction cavity, was in operation by 1955 with an accuracy of one part in one billion (1×10^{-9}).

NBS Atomic Frequency Standards

The NBS Time and Frequency Division in Boulder, Colo., maintains two of the world's most accurate frequency standards. Referred to as NBS-4 and NBS-5, these devices have been completed in the last 2 years, strengthening a quarter-century of NBS involvement in establishing molecular and atomic-beam frequency standards. Since 1960, several generations of NBS cesium-beam devices have provided our Nation and NBS with a primary frequency standard.

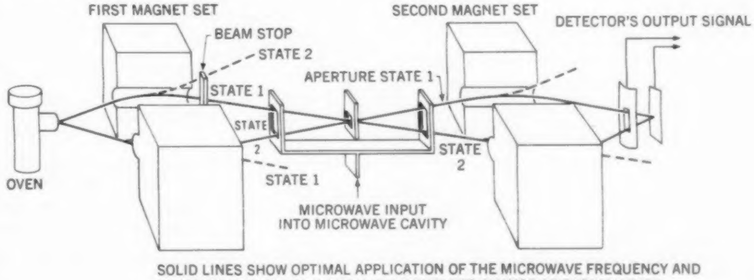
Forming a system in which they mutually support each other, NBS-4 and NBS-5 provide accuracies approximately 100,000 times better than the second of time as measured by our revolving earth. If NBS-5 were allowed to run constantly for one million years without adjustment, it would still be accurate to better than 10 seconds!

Contributing to World Time

NBS atomic clocks are direct contributors to the world's uniform time system, Coordinated Universal Time (UTC), maintained by the Bureau International de l'Heure (BIH) in Paris, France. Since NBS-4 and NBS-5 form the primary NBS standard, their frequencies are periodically used to check and calibrate an ensemble of continually running commercial cesium clocks. This standard and ensemble form the NBS atomic clock system, which generates the necessary atomic time disseminated by several NBS methods.

Time and frequency signals, covering over half the world, are broadcast 24 hours a day from three NBS radio stations: WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz; WWVB—60 kHz; and WWVH—2.5, 5.0, 10.0, 15.0, and 20.0 MHz. WWV and WWVB transmitters are located near Fort Collins, Colo.; WWVH transmits from the Island of Kauai in the Hawaiian Islands. A time-of-day telephone service is also provided by WWV (303/499-7111) and WWVH (808/335-4214). During the past 2 years, NBS has additionally offered time-of-day signals from a NASA geostationary satellite that covered the North and South American continents and the Atlantic and Pacific Oceans. □

SCHEMATIC ILLUSTRATION OF MAJOR COMPONENTS AND BEAM PATHS OF NBS-5
Vertical Scale Exaggerated



SOLID LINES SHOW OPTIMAL APPLICATION OF THE MICROWAVE FREQUENCY AND POWER TO THE CAVITY TO EFFECT A COMPLETE CHANGE OF ENERGY STATE.

WHERE *continued*

deuterium, an isotope of hydrogen, abundant in our oceans and atmosphere. If an efficient method of fusion can be found, virtually unlimited supplies of hydrogen will be available for our energy production.

Although NBS is not directly involved in fusion as such, our radiation research, especially in the area of standards development, and certain spectroscopy studies, can help illuminate the obscure fusion process.

But at best there are probably decades ahead of concern with conservation efforts and with interim energy-producing modes.

Even with final success, however, one more obstacle must be overcome. People must accept and trust nuclear power. Everyone knows the destructive potential of splitting and combining atoms. But properly harnessed, nuclear power is a gentle giant capable of benefitting man and, especially in the case of "clean" fusion, the environment. □

SCHOOL *continued*

The second phase consists of a design analysis of the building enclosure and energy systems. The new energy efficient school is likely to have additional thermal insulation and double-pane windows. Also, recovery of heat from the exhaust air (68 °F) to warm incoming cold air for ventilation holds promise as a technique for saving energy. The school design will take into account design parameters such as size, height, aspect ratio (length to width proportions), site orientation, fenestration (window arrangement), solar shading and wall and roof materials. Some of the concepts may deviate from conventional practice and violate existing building codes. However, should all parties involved agree that fuel consumption can be reduced significantly, without jeopardizing the students' instruction or well-being, the education board reportedly is prepared to request a waiver of selected code requirements.

National Model

One problem for builders as well as for funders of these projects is to justify the additional first-cost of the insulation, special glass or energy conserving utility systems. A recent study of insulating glass conducted by a private firm[1] showed that an additional first-cost of $122,000 for installing double insulating glass in an office building was fully offset by reduction of $123,000 for the smaller heating and cooling systems need. The decrease in energy used by the smaller systems is expected to save an additional $40,000 annually.

If this experimental school building proves to be significantly energy conserving, it could serve as a national model.

Frank Powell, Chief of NBS Thermal Engineering Systems Section of CBT, says:

"The design professions could immediately use the energy conservation features in their own designs. Further, if design features that violate existing codes are proved safe and energy efficient, the basis for a change in code provisions will be established." □

[1] For additional information see Technical Note 789, Technical Options for Energy Conservation in Buildings. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.35.

OFFICE BUILDING *continued*

Except for the fourth floor, there will be no individual rooms. Instead, partial dividers will section work areas so that any one desk in the entire building can be lighted while the rest remain dark. Desks and other work areas will be well lighted. Stairwells will be somewhat dimmer, while corridors and lobbies can be sufficiently illuminated with even less use of electricity.

NBS will be monitoring the building with over 700 transducers which will include temperature sensors, relative-humidity sensors, air-flow indicators and other instruments to verify energy consumption rates of the building. Since this is a demonstration building, it is planned that the first-floor lobby will have various display cases set up to explain to the public the energy-conserving features used in the building. □

DESIGN DIFFERENCES BETWEEN MANCHESTER PROJECT AND NORMAL OFFICE BUILDINGS

	NORMAL OFFICE BUILDINGS	MANCHESTER PROJECT
Shell Design	50-60% windows	13% windows (including north side area)
	single-pane glass	double-pane glass
	unshaded windows	windows shaded, fins and overhang
	6cm. (1½ in.) insulation on inside (of)	7 cm. (3 in.) insulation on outside (of)
	10-15 cm. (4-6 in.) of concrete	30 cm. (12 in.) of concrete
Utility Design	all utilities fuel-consuming	only two units fuel-consuming
	all electricity purchased	engine-generator-produced electricity for cooling
	single large boiler	modular boilers, plus solar collector
	absorption chiller requiring additional fuel consumption	absorption chiller works on waste heat
	domestic hot water heating requiring additional fuel	waste heat from engine-generator warms domestic hot water
	variable air temperature	variable air volume heating
	wasteful lighting arrangement	zone lighting, with different levels for different areas

PUBLICATIONS

of the National Bureau of Standards

Atomic and Molecular Studies

Fuhr, J. R., and Wiese, W. L., **Bibliography on Atomic Transition Probabilities July 1971 through June 1973,** Nat. Bur. Stand. (U.S.), Spec. Publ. 320 Suppl. 2, 63 pages (Nov. 1973) 95 cents, SD Catalog No. C13.10:320.

Building Technology

Fung, F. C. W., Suchomel, R., and Oglesby, P. L., **NBS Corridor Fire Tests: Energy and Radiation Models,** Nat. Bur. Stand. (U.S.), Tech. Note 794, 127 pages (Oct. 1973) $1.40, SD Catalog No. C13.46:794.

Wright, R. N., and Kramer, S., **Building Performance in the 1972 Managua Earthquake,** Nat. Bur. Stand. (U.S.), Tech. Note 807, 155 pages (Nov. 1973) $1.60, SD Catalog No. C13.36:807.

Computer Science and Technology

Neumann, A. J., **Network User Information Support,** Nat. Bur. Stand. (U.S.), Tech. Note 802, 27 pages (Dec. 1973) 60 cents, SD Catalog No. C13.46:802.

Neumann, A. J., **User Procedures Standardization For Network Access,** Nat. Bur. Stand. (U.S.), Tech. Note 799, 43 pages (Oct. 1973) 70 cents, SD Catalog No. C13.46:799.

Consumer Information Electronic Technology

Beatty, R. W., **Applications of Waveguide and Circuit Theory to the Development of Accurate Microwave Measurement Methods and Standards,** Nat. Bur. Stand. (U.S.), Monogr. 137, 322 pages (Aug. 1973) $5.20, SD Catalog No. C13.44:137.

Bullis, W. M., Ed., **Methods of Measurement For Semiconductor Materials, Process Control, and Devices. Quarterly Report, April 1 to June 30, 1973,** Nat. Bur. Stand. (U.S.), Tech. Note 806, 77 pages (Nov. 1973) $1.00, SD Catalog No. C13.46:806.

Weidman, M. P., and Engen, G. F., **Application of a Non-Ideal Sliding Short to Two-Port Loss Measurement,** Nat. Bur. Stand. (U.S.), Tech. Note 644, 40 pages (Oct. 1973) 50 cents, SD Catalog No. C13.46:644.

Engineering and Information Processing Standards

Newell, K. G., Jr., **Structural Glued Laminated Timber, (ANS A190.1–1973),** Nat. Bur. Stand. (U.S.), Prod. Stand. 56–73, 12 pages (Oct. 1973) 45 cents, SD Catalog No. C13.20/2:56–73.

Health and Safety

Slater, J. A., **Fire Incidents Involving Sleepwear Worn by Children Ages 6–12,** Nat. Bur. Stand. (U.S.), Tech. Note 810, 23 pages (Dec. 1973) 50 cents, SD Catalog No. C13.46:810.

Waksman, D., Ferguson, J. B., Godette, M., and Reichard, T., **Potential Systems For Lead Hazard Elimination: Evaluations and Recommendations For Use,** Nat. Bur. Stand. (U.S.), Tech. Note 808, 21 pages (Dec. 1973) 50 cents, SD Catalog No. C13.46:808.

Instrumentation

Yates, B. C., and Counas, G. J., **Summary of WR15 Flange Evaluation at 60 GHz,** Nat. Bur. Stand. (U.S.), Tech. Note 642, 32 pages (Oct. 1973) 40 cents, SD Catalog No. C13.46:642.

Measurement Science and Technology

Glass, A. J., and Guenther, A. H., Ed., **Laser Induced Damage in Optical Materials: 1973. Proceedings of a Symposium Sponsored by Office of Naval Research, The American Society for Testing Materials and by the National Bureau of Standards, Boulder, Colo. May 15–16, 1973,** Nat. Bur. Stand. (U.S.), Spec. Publ. 387, 285 pages (Dec. 1973) $2.65, SD Catalog No. C13.10:387.

Gramlich, J. W., Murphy, T. J., Garner, E. L., and Shields, W. R., **Absolute Isotopic Abundance Ratio and Atomic Weight of a Reference Sample of Rhenium,** J. Res. Nat. Bur. Stand. (U.S.), **77A** (Phys. and Chem.), No. 6, 691–698 (Nov.-Dec. 1973).

Hastie, J. W., **Molecular Basis of Flame Inhibition,** J. Res. Nat. Bur. Stand. (U.S.), **77A** (Phys. and Chem.), No. 6, 733–754 (Nov.-Dec. 1973).

Johnson, G. R. A., **Radiation Chemistry of Nitrous Oxide Gas. Primary Processes, Elementary Reactions, and Yields,** Nat. Stand. Ref. Data. Ser., Nat. Bur. Stand. (U.S.), 45, 27 pages (Dec. 1973) 60 cents, SD Catalog No. C13.48:45.

Mavrodineanu, R., and Lazar, J. W., **Standard Reference Materials: Standard Quartz Cuvettes For High Accuracy Spectrophotometry,** Nat. Bur. Stand. (U.S.), Spec. Publ. 260-32, 27 pages (Dec. 1973) 55 cents, SD Catalog No. C13.10:260-32.

Mielenz, K. D., and Mavrodineanu, R., **Reflection Correction For High-Accuracy Transmittance Measurements on Filter Glasses,** J. Res. Nat. Bur. Stand. (U.S.), **77A** (Phys. and Chem.), No. 6, 699–703 (Nov.-Dec. 1973).

Oberholtzer, B. L., **Publications of the National Bureau of Standards 1972 Catalog. A Compilation of Abstracts and Key Word and Author Indexes,** Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 4, 449 pages (July 1973) $3.75, SD Catalog No. C13.10:305 Suppl. 4.

Peiser, H. S., McNeil, M. B., and Bluebond, D. M., Ed., **Collaborative Research Program Between NBS and Indian Scientific Institutions. Special Foreign Currency Program 1973 Status,** Nat. Bur. Stand. (U.S.), Tech. Note 798, 139 pages (Nov. 1973) $1.50, SD Catalog No. C13.46:798.

Schramm, R. E., Clark, A. F., and Reed, R. P., **A Compilation and Evaluation of Mechanical, Thermal, and Thermal and Electrical Properties of Selected Polymers,** Nat. Bur. Stand. (U.S.), Monogr. 132, 848 pages (Sept. 1973) $10.25, SD Catalog No. C13.44:132.

Sinnott, G. A., **Bibliography of Ion-Molecule Reaction Rate Data (January 1950-October 1971),** Nat. Bur. Stand. (U.S.), Spec. Publ. 381, 73 pages (Oct. 1973) $1.00, SD Catalog No. C13.10:381.

Thompson, R. C., and Hilsenrath, J., **An Edit Insert Program For Automatic Typesetting of Spectroscopic and Other Computerized Tables,** Nat. Bur. Stand. (U.S.), Tech. Note 740, 30 pages (Dec. 1973) 55 cents, SD Catalog No. C13.46:740.

Publications listed here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, Va. 22151. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: TRA Room A640 Administration Building, National Bureau of Standards, Washington, D.C. 20234.

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